Estimating the frequency of tap water exposures to *Mycobacterium avium* complex (MAC) in the U.S. population with advanced AIDS

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Abstract

Mycobacterium avium complex (MAC) is a group of ubiquitous and opportunistic bacterial pathogens included on the U.S. Environmental Protection Agency's Drinking Water Contaminant Candidate List. The infection risk from MAC-contaminated tap water ingestion appears to be primarily limited to the immunocompromised including those with advanced Acquired Immunodeficiency Syndrome (AIDS). $CD4^+$ cell counts, which decline as AIDS progresses, are a strong predictor of MAC infection risk in the AIDS population. There is insufficient epidemiologic evidence to determine whether exposure to tap water, food and soil are risk factors for the development of MAC infection among the AIDS population. We developed an exposure assessment targeting the U.S. population with advanced AIDS, defined here as having less than 100 $CD4^+$ cells/mm^3 of peripheral blood. Using limited data on the detection of MAC and self-reported tap water ingestion among individuals in the U.S. with human immunodeficiency virus (HIV) infection and AIDS, we developed two exposure models. We estimate that approximately 1500 individuals with advanced AIDS ingest tap water with detectable concentrations of MAC organisms each day. Two important research needs emerged from this exposure assessment. Longitudinal and cross-sectional studies are needed on the occurrence of MAC in tap water, particularly in regions of the U.S. with large HIV^+/AIDS populations. Studies are needed to characterize tap water usage among the HIV^+/AIDS population.

Background

- MAC are ubiquitous, opportunistic bacterial pathogens
- MAC is on EPA's Drinking Water Contaminant Candidate List
- MAC causes disseminated infections in individual with advanced AIDS (Below 100 $CD4^+$ T-lymphocytes/ μm Blood)
- Disseminated MAC infections associated with significant morbidity and mortality
- MAC infection incidence in U.S. AIDS population declining due to antiretroviral therapies, but remains significant source of morbidity and mortality
  - Incidence in 2000 = 2 cases/100 person-years
- To reduce exposures to pathogens, the CDC advises immunocompromised persons to boil or filter their water prior to consumption

Objective

Estimate the frequency of tap water exposures to detectable levels of MAC in the U.S. HIV^+/AIDS population

Methods

For U.S. population with advanced AIDS, two MAC Tap Water Exposure Models were developed

Implemented Using Monte Carlo Simulation
Exposure Equation

$$Pe = 1-\exp(-Cr/\theta)$$

Pe daily probability of exposure in susceptible population
Cr drinking water consumption rate (L/day)
θ mean water quantity measured w/o detecting MAC (L)

Assumptions

- Occurrence studies provide unbiased estimates of the fraction of U.S. tap waters with detectable concentrations of MAC (3% to 7%)
- Frequency of detecting MAC in tap water does not vary over time and location
- Advanced AIDS population randomly ingests these tap waters
- Post-tap treatment (filtration or boiling) 100% effective in removing MAC
- 5-10% of U.S. HIV-infected population has advanced AIDS
- No person-to-person transmission

Summary of Parameter Values used in Exposure Model 1*

Parameter	Distribution
Cr, Tap Water Consumption Rate	Lognormal geo. mean =0.9 L/day and geo. st.dev.= 1.7 L/day min=0.01 L/day max = 13 L/day
θ, water quantity measured w/o detecting MAC	Uniform (min= 10 L; max= 22 L)
Size U.S. Population with advanced AIDS	5-10% of U.S. HIV^+ Population (n = 900,000)
Fraction of AIDS Population *not* consuming tap water	Uniform (min= 20; max = 43)
Fraction of AIDS Population *always* consuming tap water	12.2%
Fraction of AIDS Population consuming *some* tap water	45-67%
Fraction of AIDS Population that treats tap water prior to consumption	50%
Fraction of tap water consumed in AIDS population that consumes *some* tap water (no further treatment) relative to general population	Uniform (min= 0.01; max = 0.5)

*In Model 2 the fraction of population with advanced AIDS consuming tap water without further treatment is estimated using Davis et al. (1998.)

Exposure Model 1

Fleming et al., 2002
U.S. HIV Population (900,000) → Fraction of U.S. AIDS Population with < 100 $CD4^+$ cells/mm^3 blood (5%-10%)

Aragon et al., 2003; Kim et al., 1998
No Tap Water Consumption → Not At Risk (21-43%)
Always Consume Tap Water (12%)
Some Tap Water Consumption (45-67%)

Eisenberg et al., 2002
Further Treat → Not At Risk Tap Water (50%)

MAC Exposures in AIDS Population with CD4+ < 100/mm^3 (mean = 650 individuals with advanced AIDS ingest detectable levels of MAC/day)

Exposure Model 2

Fleming et al., 2002
U.S. HIV Population (900,000) → Fraction of U.S. AIDS Population with < 100 $CD4^+$cells/mm^3 blood (5-10%)

Davis et al., 1998

Tap Water as Percentage of Total Water Consumed	Fraction of HIV Population (%)
100	18
76-99	28
51-75	8
26-50	6
1-25	16
None	26

MAC Exposures in AIDS Population with $CD4^+$ < 100/mm^3 (mean = 2,400 individuals with advanced AIDS ingest detectable levels of MAC/day)

Results

Combining both model results, approximately 1,500 individuals with advanced AIDS exposed to MAC via tap water ingestion each day.

Mean = 1,500 individuals per day; SD= 1,100

Median = 1,200 individuals per day

Limitations

We did not evaluate:

Inhalation exposures
Exposures in children
Exposures through recreational water uses
Exposures to MAC-contaminated foods

Research Needs

Develop sensitive and accurate quantification methods for MAC; evaluate the under-reporting associated with the harsh isolation practices of current methods.

Implement long-term evaluations of MAC levels in randomly selected tap water samples in the U.S., examining seasonal and geographic variability; conduct additional occurrence studies targeting U.S. regions with increased MAC prevalence and large HIV+ populations.

Conduct epidemiologic studies in U.S. AIDS populations to examine the association between MAC infection and detailed tap water use information.

Develop studies of tap water usage in U.S. AIDS populations to determine inter-individual variability in both water consumption rates and post-tap treatment.

Currently, not possible to characterize the risk posed by MAC in drinking waters because there are no adequate dose-response data for MAC. Develop approaches to estimate MAC dose-response relations among sensitive populations.

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